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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

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Commercial Refrigeration

The Means Involved, and the Importance of Machine Lubrication

THE science of refrigeration, in its application to the preservation or storage of foodstuffs, furs and beverages, and the maintenance of constant atmospheric conditions in public buildings, as well as industrial plants, is of vital interest today. Although it chiefly involved the manufacture of ice, in its early development, the cooling of air or cold-storage compartments by means of certain chemicals having refrigerating properties has assumed a decidedly prominent position in the course of our present-day mode of living.

Refrigeration, where it involves the cooling of air, is especially advantageous when sanitation or handling of water may develop problems.

METHODS INVOLVED

Refrigeration may be direct or indirect, according to the design and construction of the system, the products to be treated and the manner in which the refrigerant is handled.

Direct Refrigeration

In such systems the refrigerant is used directly to cool the storage compartment or ice tanks by allowing it to expand in suitable coils located therein.

The Indirect Method

Here, however, air or brine is subjected to preliminary cooling by circulation over expansion coils containing the refrigerant, in a separate compartment or room for this purpose. The medium thus cooled is then passed to the refrigerating rooms or storage compartments, wherein the temperature is to be reduced. This is the normal procedure in the operation of a cold storage system.

PRINCIPLES OF OPERATION

The phenomenon of refrigeration involves

(1) Expansion and evaporation of the refrigerant, whereby heat is absorbed from the surroundings and

(2) Compression and condensation, whereby this heat is in turn abstracted from the refrigerant and the latter converted to liquid form once again.

REFRIGERATING ELEMENTS

A number of chemicals are in commercial use today as refrigerants.

Anhydrous ammonia (NH_3), or ammonia free from water, is most commonly used. Under normal conditions this chemical occurs as a gas, but by either or both decreasing the temperature and increasing the pressure it may be readily liquefied.

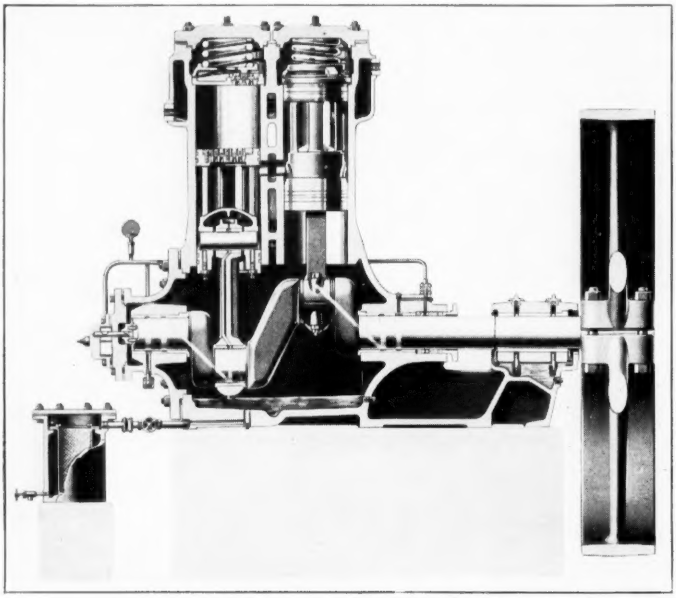
Other chemicals which are employed to a certain lesser extent are carbon dioxide (CO_2) ethyl and methyl chlorides, sulfur dioxide (SO_2), and certain hydrocarbons such as ethane, propane, iso-butane and butane.

Anhydrous Ammonia

The handling of ammonia in the process of refrigeration can be made to involve either wet or dry compression.

Wet Compression

This is attained either by the introduction of liquid ammonia directly into the compressor cylinder at the beginning of the compression stroke, or by operating so that somewhat more liquid ammonia than can be evaporated is passed into the refrigerator coils.



Courtesy of The Vilter Manufacturing Co.

Fig. 1—Phantom view of a Vilter twin cylinder vertical compressor, designed for force-feed lubrication. Note that flow of oil to the main bearings, connecting rod and wrist pin bearings is much the same as in a full force-feed automotive engine lubricating system. Return oil passes through a strainer prior to re-circulation.

Subsequently this liquid returns to the compressor with the balance of the refrigerant which has been vaporized, and is itself evaporated on the compression stroke by the heat of the compressor. Its presence serves to effectively decrease compression temperatures and increase the volumetric efficiency of the machine.

The operator of a wet compression system, however, can never be certain that the excess liquid has become vaporized at the end of the suction stroke, regardless of the attention given to the machine.

Dry Compression

Dry compression constitutes the passing of ammonia vapor alone into the compressor. It involves the same operating principles as wet compression with the exception that discharge temperatures are somewhat higher.

Carbon Dioxide

Refrigeration by means of carbon dioxide, or carbonic anhydride (CO_2) as it is also known, involves an arrangement of machinery and equipment much similar to an ammonia compression system. In fact, the essential difference (other than in regard to certain details of construction in view of the higher pressures involved) is in the cooling medium or refrigerant employed.

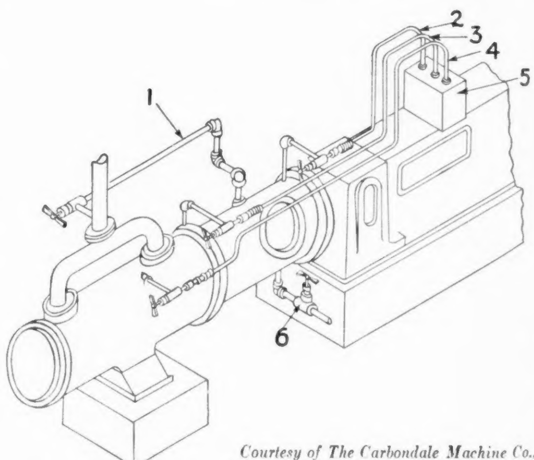
Carbon dioxide is non-explosive, odorless, non-combustible, a fire extinguisher and neutral in its action upon foodstuffs, fabrics and other substances which may require cold storage. Normal leakage is, therefore, not generally harmful even though it may be more prevalent due to the higher pressures involved.

Carbon dioxide systems include both horizontal and vertical compressors, according to the type of service and refrigerating capacity involved.

Single and double acting compressors are in use, but due to the difficulty in maintaining tight stuffing boxes the single acting machine is often preferred. Frequently pressures as high as 1,000 pounds or more may be necessary; therefore it is evident that the system must be of exceptional rigidity.

Ethyl Chloride and Methyl Chloride

Ethyl and methyl chlorides are comparatively stable, non-poisonous, slightly inflammable chemicals, readily subject to low working pressures. They are practically neutral, chemically, and have no appreciable effect on the usual metals employed in machine construction.



Courtesy of The Carbondale Machine Co., and Worthington Pump & Machinery Corp.

Fig. 2—Details of oil piping for double seal stuffing box on a Worthington horizontal compressor. 1, indicates vent from double seal chamber to suction; 2, is the oil feed to outer stuffing box; 3, the oil feed to inner stuffing box; 4, the oil feed to ammonia cylinder; 5, the 3-feed oil pump; and 6, the drain.

Sulfur Dioxide

Where but a small amount of refrigerant is required the use of sulfur dioxide as the refrigerating medium is practicable. As a liquid, sulfur dioxide is colorless, but has a strong odor and can be readily detected. It is soluble in water, in which solution it is strongly acidic.

Hydrocarbon Refrigerants

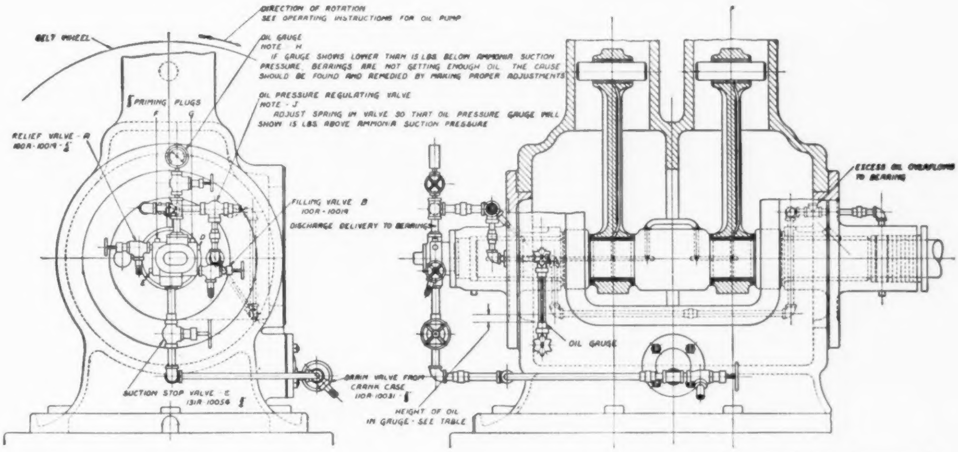
Hydrocarbon refrigerants are also used to some extent, especially for household and retail business purposes. These chemicals have a distinct property in that lower temperatures are made possible by their application.

Products such as ethane, butane, etc., are non-corrosive, chemically neutral towards water, relatively stable under ordinary conditions, non-poisonous, and can be handled in the same equipment as is required for ammonia. They are, however, inflammable in the presence of open flames.

Silica Gel

An extremely interesting factor in the development of refrigerator cars has been the adoption of Silica Gel as a cooling medium, using its vapor absorption ability.

In the operation of such a system no power is required; heat, however, is necessary to drive the absorbed refrigerating vapor from the Silica Gel. Compressed gas is used for this purpose. The cycle of operation is continuous, involving absorption of the refrigerant to a point of saturation, followed by heating to drive off this vapor. The process of absorption of refrigerating vapor lowers the temperature of the refrigerant itself, due to evaporation.



Courtesy of Frick Company, Inc.

Fig. 3—Showing details of the force-feed oiling system in a Frick vertical enclosed type compressor. Details of construction are clearly shown.

HOW REFRIGERATION IS ACCOMPLISHED

The various types of refrigerating machines in more or less common use can be definitely grouped into two distinct classifications, according to the methods involved, i.e.:

(1) Where refrigeration is produced by the evaporation of some volatile liquid;

(2) Where refrigeration is effected by the compression cooling and expansion of air.

The first classification can be subdivided into three groups, according to whether the principles of (a) compression, (b) absorption, or (c) vacuum, are employed.

Refrigeration by Compression

The compression process is chiefly used today. Such a system includes a compressor, oil separator, condenser, expansion valve and an evaporator or refrigerator.

Compressors may be either single or double acting, according to the size of the installation and extent of refrigeration required.

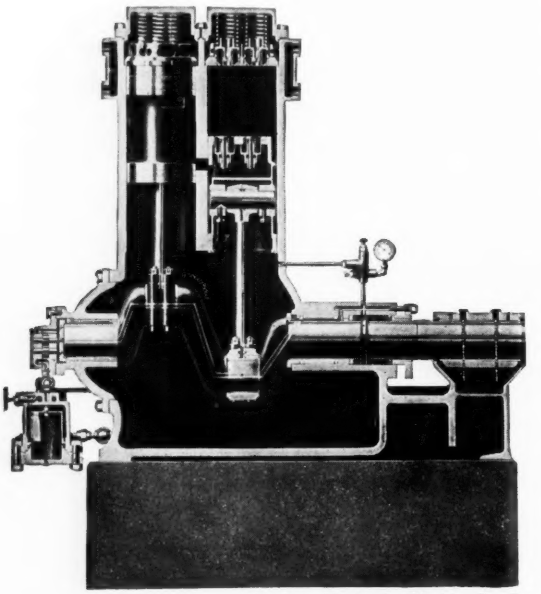
In the compression process the refrigerant or cooling agent is recovered after each expansion by means of mechanical compression. With certain variations in construction and arrangement of equipment, the compression process is adaptable to such refrigerating agents as ammonia, carbon dioxide, methyl chloride, sulphur dioxide and certain hydrocarbons, etc.

In operation, the gaseous refrigerant in a compression system must be sufficiently compressed and cooled to convert it to liquid form.

Under compression alone, it will still remain as a gas due to the fact that the application of

pressure raises the temperature above the liquefaction point. Some form of condenser must therefore be used.

Prior to condensation, however, the gas is usually passed through a suitable oil separator



Courtesy of Baker Ice Machine Co., Inc.

Fig. 4—Showing a phantom view of a Baker vertical compressor, with provision for force-feed lubrication. Note gear pump and oil strainer at the outboard end of the machine. Path of oil through crank shaft and connecting rod is clearly shown.

or trap in order to free it of any excess lubricant that may have gained entry into the compressor. From the oil separator the hot refrigerant then passes to the cooling coils of the condenser, where its temperature is sufficiently lowered by means of air or cold circulating water to convert it to liquid form. It is then capable of serving as a cooling medium.

Cooling is brought about by passing it through an expansion or regulating valve to the expansion side of the system. Here, by virtue of a considerable drop in pressure it evaporates and takes up heat, returning thereafter to gaseous state once more. In so doing it cools down to a relatively low temperature, and as a result absorbs heat from the surroundings, whatever these may be. It is then returned to the compressor to commence this cycle of operation anew.

The Absorption Process

Here we make use of the fact that certain low-boiling-point vapors are readily absorbed by water, being capable of subsequent separation by fractional distillation upon the application of heat.

Absorption refrigeration involves pumps instead of compressors, one working below atmospheric pressure, the other above.

Ammonia the Most Usual Refrigerant

Ammonia is principally used in absorption refrigeration due to its relatively high affinity for water and the readiness with which it can be distilled off under pressure and temperature conditions where water is unaffected. The latter is, therefore, able to remain in a liquid state.

Absorption refrigeration involves three stages or sets of equipment, whereby the ammonia is first distilled in a suitable steam heated generator, freed from any water vapor in an analyzer, and liquefied by passage through a suitable condenser.

It is then ready for the second, or refrigeration stage, being passed to an evaporator or set of cooling coils.

The third stage usually comprises the passing of the gaseous ammonia under its own pressures to an absorber, where it is taken up by a weak ammonia solution. When suitable concentration of the latter has been attained it is pumped back to the generator, and the cycle begun anew.

Lubrication—The Salient Factor in Operation

Effective lubrication is of decided importance in the operation of refrigerating machinery. Oil in any part of a cooling system will tend to reduce refrigerating efficiency due to its becoming so sluggish under the low temperatures involved as to form an interior lining in the expansion coils and materially affect the heat transfer.

Lubrication of refrigerating machinery is exceptional in that we must consider the action and effects of the lubricants upon parts not requiring lubrication as well as upon the actual wearing surfaces. As a result, considerable care and judgment must be used in selecting the lubricants.

MEANS OF LUBRICATION EMPLOYED

Splash and pressure lubrication predominate in refrigerating compressors today. The latter is suited for the lubrication of both vertical and horizontal machines. The former, however, is more adapted to the vertical compressor.

The system involved for the lubrication of compressor cylinders, stuffing boxes and enclosed bearings will have a decided influence upon the grade of the oil that should be used.

It will, therefore, be of interest to study the principles involved in these methods of lubrication.

Splash Systems

Splash lubrication constitutes distribution of the oil at each revolution of the crank, the level in the crank-case being maintained just high enough to permit the crank to dip and splash the necessary amount of oil to the cylinder walls, etc.

Continued operation will result in the crank-case being filled with a lubricating vapor above the main body of oil, which will insure adequate lubrication of main, wrist pin and crank pin bearings as well.

Careful attention is necessary, especially when re-charging the case with oil, to see that the level is not raised too high. The result would be churning by the crank, bringing about such violent agitation in the main body of oil as to oftentimes preclude effective precipitation of any impurities that may have gained entry. There would also be possibility of loss of lubricant past the piston rings, with subsequent entry of an excess of oil into the condensing and evaporating parts of the system.

Piston Rings Must Be Properly Adjusted

Another point to remember in this regard is that where piston rings are not sufficiently tight, if the crank-case contains too much oil or agitation is too violent, the excess which naturally will reach the cylinder walls will tend to work past the rings, as occurs frequently in an automobile engine.

This is often termed oil pumping. Not only is it wasteful, but especially in an ammonia compression system will it be a detriment, for oil in the refrigerating lines will impose an added load on the oil separator. Furthermore, if by chance the oil is not of sufficiently low pour test there will be a possibility of its congealing within the system, reducing refrigeration to a marked degree.

Excess Oil a Detriment

Use of excess oil in a splash lubricated system will also involve the possibility of difficulty when draining and cleaning, especially where sludging has taken place.

Churning of certain oils in a crankcase will give rise to sludge formation if they have not been very highly refined. In part this is due to oxidation; it will be most probable where water is present or the oil is laden with foreign matter, such as dirt, metallic particles, or carbon.

It is, therefore, important to follow regular periods for cleaning, and to look carefully into the condition of the used oil, for this will very often indicate both the approximate suitability of the latter and the extent to which effective lubrication is being attained.

Courtesy of Brunswick-Kroeschell Co.

Fig. 5—Details of the Brunswick-Kroeschell eccentric drive for vertical ammonia and carbon dioxide compressors. Note in particular the ball bearing wrist-pin, which materially reduces power consumption, facilitates lubrication and renders possible the replacement of any individual parts without disturbing the others.

Pressure Lubrication

With many types of vertical or horizontal refrigerating machines, pressure lubrication is used with marked success.

With such a system, more accurate control of the amount of oil delivered to cylinder walls and compressor bearings is made possible. On the other hand, it may require more equipment, piping, etc., and frequent filling of the reservoir (where a mechanical force feed lubricator is involved) and more attention from the operator than where splash lubrication is employed.

One of the chief advantages of pressure lubrication, however, is the possibility of effective filtration or purification of the oil where there is provision for circulation.

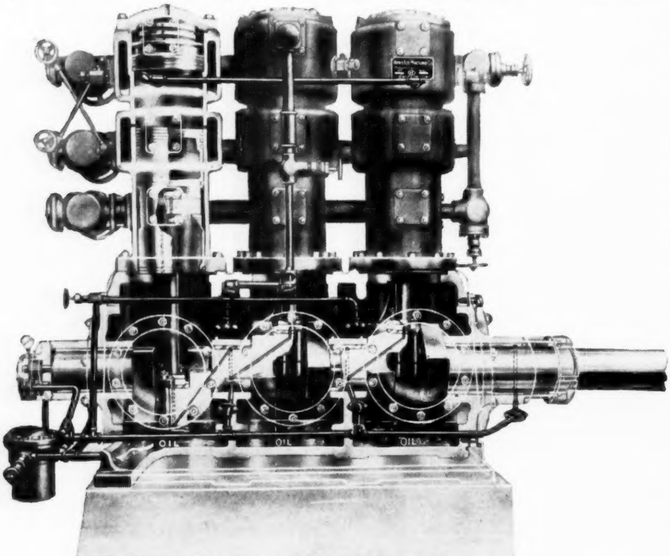
Mechanical Force Feed Oilers Adaptable

Mechanical force feed lubricators are extensively used where compressor cylinders are to be pressure oiled. Excellent economy will be attained by regulating such lubricators so that just enough oil is delivered to maintain the requisite lubricating films, with the least amount of excess to drain off.

On many types of machines it is good practice to lubricate internal and external parts individually. In other words, using the mechanical lubricator with perhaps three outlets for cylinder and stuffing box service, and an independent gravity or mechanical pressure circulating system for all other bearings.

Requirements Involved

Mechanical force feed lubricators are especially adapted to cylinder and rod lubrication via the oil lantern, or oil recess within the piston rod stuffing box. By properly constructing a stuffing box with a lead to come from the lubricator, it is possible to operate the piston rod continually through a ring of oil. In this way effective rod lubrication, as well as sealing against pressure, can be maintained.



Courtesy of Howe Ice Machine Co.

Fig. 6—Sectional view of a Howe multiple effect compressor. Note that here again full force-feed lubrication is employed, oil being delivered by the pump directly to the center bearings from which it is distributed to all other bearing surfaces. Note, in particular, the oil piping from the gear pump to the various bearings, and path of return oil to the filter.

To lubricate the cylinder in addition, it is only necessary to deliver additional oil to the stuffing box lantern and provide a so-called overflow pipe to carry this to the refrigerant suction line adjacent to the cylinder. In effect, this is similar to the principles of steam cylinder lubrication, the refrigerating gas being impregnated with vaporized lubricant prior to its passage through the compressor.

Hand pump oilers can also be used for this purpose, but mechanical force feed lubricators are more positive and require less attention on the part of the operator.

SELECTION OF LUBRICANTS FOR AMMONIA SYSTEMS

In the selection of lubricants for cold storage and refrigeration machinery, due regard must always be given to the service involved and the operating conditions that will probably be encountered.

To overlook or disregard the importance of such factors as the method of lubrication involved, the temperature in the expansion or refrigerating coils, the mechanical condition of the compressor, etc., and the location, type and efficiency of the oil separator may frequently lead to marked increase in maintenance costs and reduction in capacity.

Lubricating oils for service in an ammonia compression system, therefore, require consideration of their pour test, and viscosity, for it is these characteristics which will be indicative of the extent and degree of success with which any lubricant will function, in accordance with the particular operating and constructional conditions.

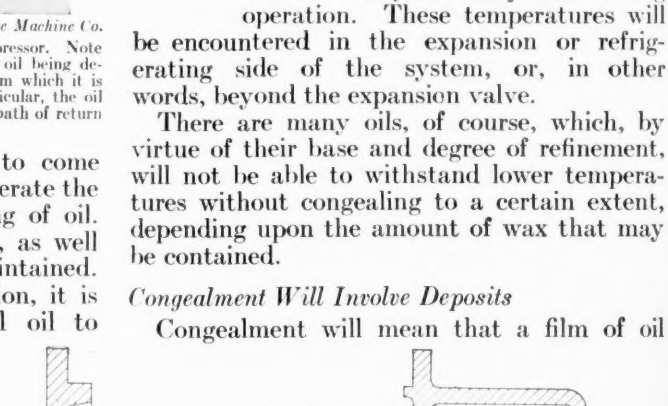
Importance of the Pour Test

The most important characteristic of an oil for refrigerating machinery lubrication is that it shall remain fluid at the lowest temperatures to which it may be subjected during operation. These temperatures will be encountered in the expansion or refrigerating side of the system, or, in other words, beyond the expansion valve.

There are many oils, of course, which, by virtue of their base and degree of refinement, will not be able to withstand lower temperatures without congealing to a certain extent, depending upon the amount of wax that may be contained.

Congealment Will Involve Deposits

Congealment will mean that a film of oil will be deposited on the inner surfaces of the refrigerating piping to form more or less of an insulating medium which will prevent proper abstraction of heat from the compartment or medium which is to be cooled. If this is al-



Courtesy of Norma-Hoffmann Bearings Corp.

Fig. 7—Showing details of a two-cylinder compressor crank case with the crank shaft mounted on Norma-Hoffmann roller bearings. Oil is pumped from a small pump outside the crank, through tubing into holes in the crank shaft. There is further provision for leading oil from the connecting rod bushings up the rods to the piston pins. The roller bearings themselves are splash lubricated.

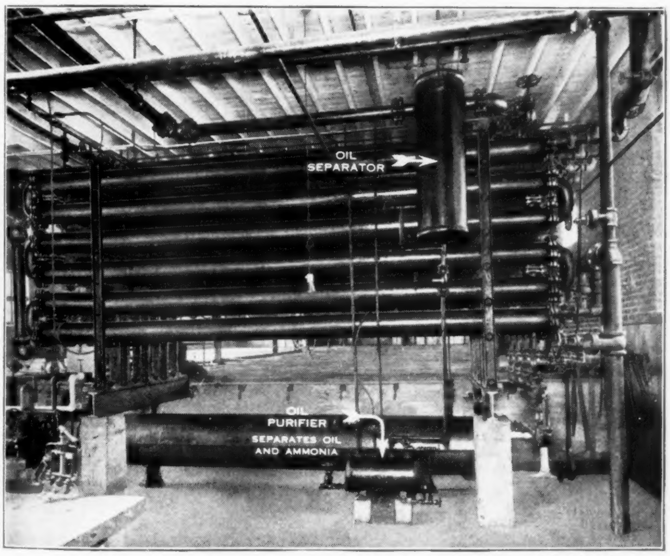
lowed to continue it is evident that the refrigerating capacity of the system will be reduced and ultimately it will be necessary to clean out these congealed oil deposits.

Water an Objection

In connection with this matter of possible congealment, consideration must also be given to water. It is essential that the oil at all times be practically free from water, otherwise this will freeze if carried over to the refrigerator coils, in which case it would probably remain in the system and result in a certain decrease in evaporative efficiency.

It is therefore necessary for the operator to use the utmost care in placing oil cans beneath snow-covered suction pipes, etc., or anywhere else where moisture might splash or drip into the contents. An excess of water can readily cause so much trouble in the evaporator coils as to necessitate shut-down of the plant until this is corrected.

An oil, to be suited to this class of service, should have a pour test sufficiently low to insure continued fluidity at the lowest temperatures prevalent in the evaporating side of the system. It should not congeal on the inner surface of the cooling coil, and there should be sufficient viscosity throughout the range of operating



Courtesy of Henry Vogt Machine Co., Inc.

Fig. 8—View of a refrigerating plant condenser with oil separator and purifier shown in relative position.

temperatures to enable it to serve at all times as an effective lubricant for the moving parts, as well as an adequate seal for the piston rings and compressor valves.

Filtered Mineral Oils Most Suitable

For such service a straight mineral filtered oil having a viscosity of about 100 to 150 seconds Saybolt at 100 degrees Fahr. will be necessary

Courtesy of Brunswick-Kroeschell Co.

Fig. 9—A Brunswick-Kroeschell vertical, two-cylinder carbon dioxide compressor of the single acting type. Bearings are splash lubricated, the cylinders and stuffing boxes being pressure oiled by a Hills-McCanna force-feed lubricator.

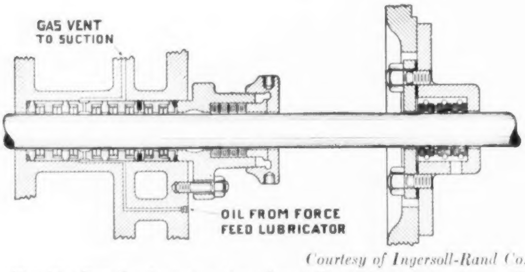
where the temperature in the refrigerating coil is below 5 degrees Fahr. Above this temperature, however, an oil of somewhat higher viscosity, i.e., 200 to 300 seconds Saybolt, will give more satisfactory results.

The purest grade of straight distilled mineral oil obtainable is always advisable in order that the above requirements will be adequately met. Oils of this nature will have a sufficient range of physical properties to lubricate compressors effectively under all normal operating conditions.

Animal and vegetable oils are not suitable for such service inasmuch as they will have a tendency to congeal at low temperatures and gum at higher temperatures. They will also react to a certain extent with ammonia, to cause the formation of sludge.

When Viscosity Must Be Considered

Viscosity is an especial factor where enclosed crankcase, high speed machines of the wet compression type are involved. As a rule, oils



Courtesy of Ingersoll-Rand Co.
Fig. 10—Details of construction of metallic packing for an Ingersoll-Rand ammonia compressor.

should be used which will stand considerable churning in the presence of the refrigerant and a certain amount of water vapor.

The one oil lubricates the entire machine. As a result, it must be capable of serving both the cylinders and bearings. It should not emulsify to any great extent, for this might result in clogging of the lubricating system or impairment of refrigeration should it work past the piston rings and over to the refrigerating side.

The physical condition of the valves, piston rings and stuffing boxes must always be considered in deciding upon the viscosity of oil to use.

Practically as important as its lubricating properties will be the seal and compression-forming ability. If the cylinder wall and moving parts are in first-class condition, a straight mineral oil of approximately 200 seconds Saybolt viscosity at 100 degrees Fahr. will be suitable.

The more worn and scored the cylinder walls and rings, naturally the higher must be the viscosity, commensurate with the pour test, to maintain the requisite seal and degree of compression. Usually an oil having a viscosity of 300 seconds Saybolt at 100 degrees Fahr. will be satisfactory in this event.

Horizontal compressor cylinders will have a greater tendency to wear out of round than those of vertical machines. Therefore, such compressors will, in general, require a somewhat heavier lubricant. It is not advisable, however, to attempt to compensate for wear by increasing the viscosity too much, due to the possibility of emulsification, and contamination of the refrigerant.

OIL SUPPLY MUST BE CONTROLLED

Wherever an excess of oil may find its way to the evaporating or cooling side of a refrigerating system, certain detriments will be involved, as have already been mentioned.

In this connection, it is interesting to discuss the means whereby this is normally prevented by use of an oil separator.

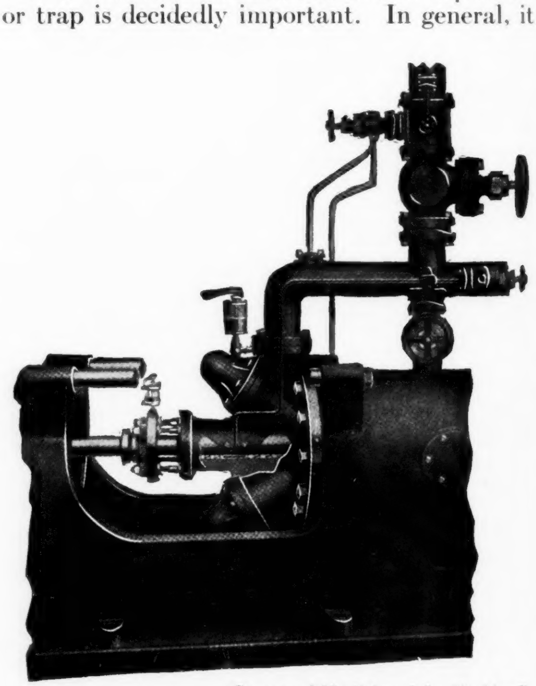
How the Separator Functions

The actual function of the oil separator is to remove any particles of oil from the refrigerant while this latter is in gaseous form, after it has left the compressor. The larger the oil particles, of course, the more effective will be the separator. It should, therefore, be located so as to permit of adequate precipitation of the oil within the ammonia gas.

The capacity of any separator should be ample so that the velocity of the gas passing through will not be too high. But we must realize that any excessive lubricant fed to the compressor will tend to impose a heavy load upon the oil separator.

Location and Installation

The manner of location of the oil separator or trap is decidedly important. In general, it



Courtesy of The Triumph Ice Machine Co.
Fig. 11—A stuffing box arrangement which illustrates the principles of compressor lubrication by means of an "oil lantern."

should be placed between the discharge of the compressor and the point of entry of the gas into the condenser.

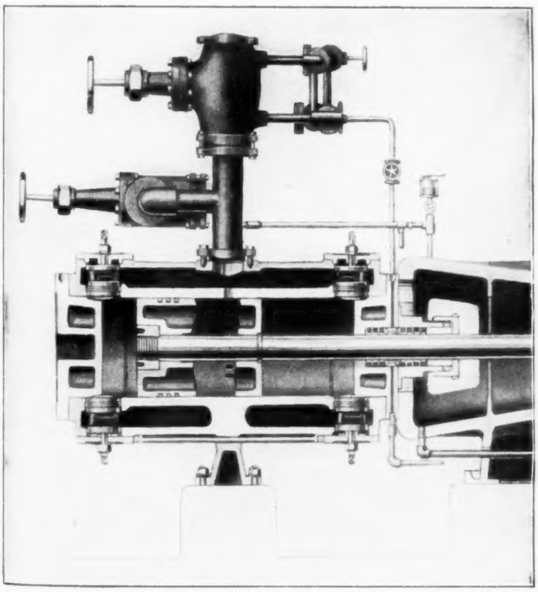
In certain machines, a purge valve may be installed under the condenser to enable removal of any oil that may have passed the separator, due to the rush of hot gas preventing proper condensation and collection of the oil.

Oil will practically always be atomized to a certain extent by virtue of the heat of compression which is prevalent. This oil vapor will naturally tend to pass into the system with the refrigerant, to condense and remain in the colder parts, unless it is effectively removed before it enters the condenser.

In consequence, the location of the separator should be carefully studied. It is always advisable that it should be of sufficient size to allow of ample reduction in the velocity of the gas in order to permit of effective separation.

Where faulty separation may occur, it is well to use an oil of as low an atomizing tendency as possible. Low atomization tendency will usually accompany high viscosity. The choice of a heavier oil would, therefore, solve the problem to some extent. In general, a viscosity of from 200 to 300 seconds Saybolt at 100 degrees Fahr. will meet these conditions satisfactorily.

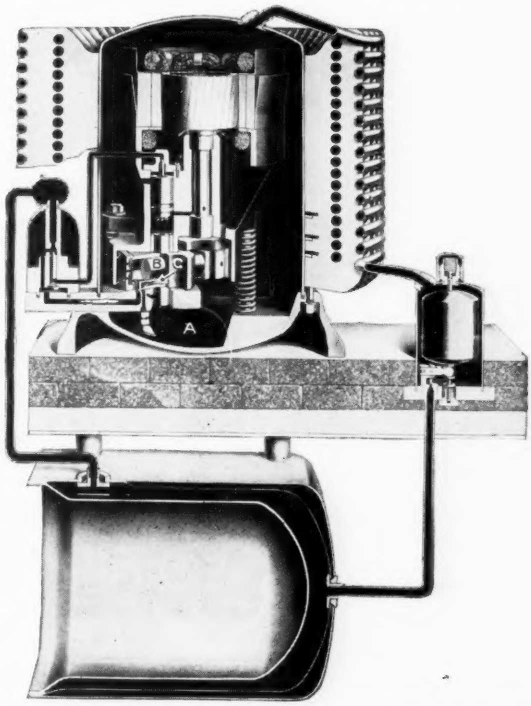
The efficiency of an oil separator can be readily checked by comparing the amount of oil removed from it with the amount fed to the



Courtesy of De La Vergne Machine Co.

Fig. 12—Cut-away view of a De La Vergne horizontal compressor cylinder showing oil piping to gas intake, and stuffing box "oil lantern," also details of construction of this latter.

compressor. Any extensive difference would indicate that the oil is not being entirely removed or trapped. Allowance, of course, should be made for oil leakage around the stuffing box, although to just what extent this may occur will depend on the individual installation, the care given to lubrication, and the original viscosity of the oil.



Courtesy of General Electric Co.

Fig. 13—Cut-away view of a General Electric icing unit, wherein sulfur dioxide serves as a refrigerant. At "B" is shown the vapor piston, "A" the oil supply, and "C" the oil piston. All moving parts are supplied with oil through the force-feed connection, which is brought about by the oil piston, connected to the crank end of the main piston. In this way oil is forced from the base of the unit around the main piston, and then to the main bearings and crank pin.

Sealing the Stuffing Box

With compressors using either ammonia or carbon dioxide, one of the most important factors is to maintain suitable stuffing box seals and properly lubricated piston rods.

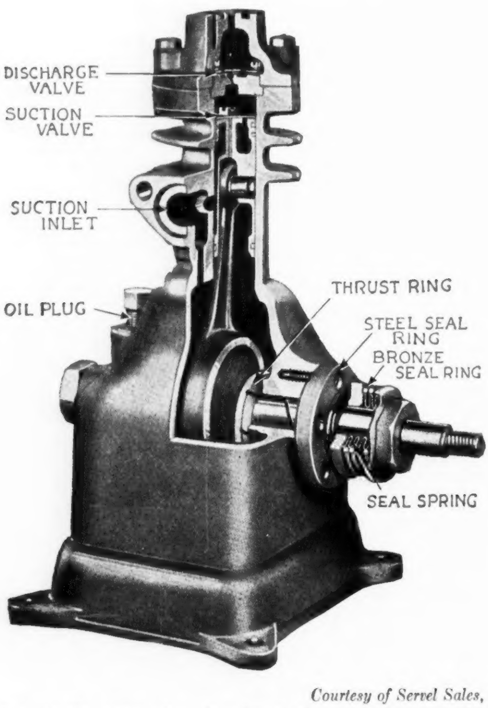
Where ammonia is involved, it is necessary to remember that this chemical has a certain corrosive action upon copper and bronze. Stuffing boxes, for such service, are therefore built of cast iron or steel (as are other parts of the compressor) and metallic (babbitt metal) asbestos, or rubber packing is used.

How the Oil Lantern Functions

In some types of machines a hollow space or "oil lantern" is located between two separate sets of packing. This space surrounds the rod and is filled with oil. It not only serves as a seal to prevent loss or leakage of ammonia,

but also as an effective means for piston rod lubrication.

Lubricant is usually fed to the "oil lantern" by means of a hand or automatic pressure oil pump.



Courtesy of Servel Sales, Inc.

Fig. 14—Cut-away view of a Servel electric refrigerator, showing details of internal construction. Splash lubrication is employed, the oil being carried in the base. This is a methyl chloride type of machine.

Where the piston rod is efficiently lubricated, its surface will have a smooth gloss and be covered with a light film of oil; there will be no indication of overheating, and a relatively perfect seal will be maintained with a minimum of leakage.

In some types of double-acting machines, the "oil lantern" serves also as a means of introducing the lubricant to the compressor cylinder by allowing it to work past the piston rod packing. There is an added advantage to this method in that certain grades of packing, which might be reacted upon by ammonia gas, will be protected by the lubricant.

More usual practice in cylinder lubrication, however, is to design compressors for pressure lubrication, using a positive oil pump or force feed lubricator which is driven from the reciprocating mechanism through a suitable connection.

Force-feed lubrication is advantageous in that the amount of lubricant supplied to the compressor is dependent upon the speed of operation. It is, therefore, dependable, economical and requisite of little attention on the part of the engineer, excepting when it is necessary to refill the lubricator. Thus, by careful adjustment and correction, it is possible to feed a definite quantity of lubricant at each stroke and at just the right time to be most effective.

RECLAIMING COMPRESSOR OILS

It is practicable to reclaim oil from an ammonia compression system by installing an ammonia distilling apparatus. This device has the dual advantage of both recovering the oil and purifying the charge of ammonia to keep same in a pure anhydrous condition without interfering with the continuous operation of the plant.

Such equipment can be connected to the discharge line oil separator and the bottom of the liquid ammonia receiver, from which oil and other impurities may be drawn, for subsequent distillation of ammonia.

After all the liquid ammonia has been evaporated and returned to the suction line of the system, the oil can then be drawn from the bottom of the still using suction pressure for this purpose. Such oil as is drawn off will contain a certain amount of gas. It should, therefore, be set aside until the gases have freed themselves. The application of a little heat will assist this operation materially.

Care should, of course, be taken in handling the distiller to prevent too rapid evaporation, which will cause a boiling-over effect and the loss of a large proportion of oil through passage back to the suction line.

After removal of the oil from the distilling system it is ready to be filtered. A separate filter should be used for this work. The size and type of filter to be used will depend upon the size of the plant and the amount of oil to be handled. Providing the original oil has been chosen with a view to giving most effective lubrication the oil recovered from the distiller, after careful filtration, can again be used for compressor lubrication.

In many plants where oil is reclaimed, however, it is used for external lubrication, and only new oil is employed for the lubrication of cylinders and other internal parts. This is safe practice, and an assurance that the oil used where service is most severe is perfectly clean and up to specifications.

Lubrication of Other Types of Refrigeration Machinery

AMMONIA ABSORPTION SYSTEMS

Perhaps the simplest of any refrigerating systems from the viewpoint of lubrication is the ammonia absorption system. Here the lubrication of such pumps as are employed involves comparatively little difficulty.

As a rule, an oil of from 200 to 300 seconds Saybolt viscosity at 100 degrees Fahr. will serve to lubricate external bearings effectively.

CARBON DIOXIDE COMPRESSORS

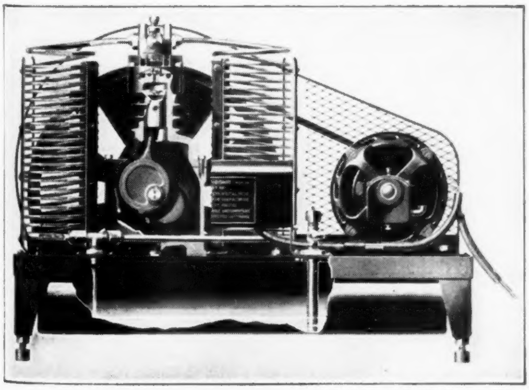
From an operating and constructional point of view there is a decided similarity between both ammonia and carbon dioxide compressors.

The marked difference in pressures, however, often requires separate consideration in regard to lubrication.

For such machinery the lubricant should be a straight mineral oil having essentially the same characteristics as for a dry ammonia compression system; such as low pour test, and a viscosity ranging from 100 to 300 seconds Saybolt at 100 degrees Fahr., dependent upon operating conditions and the pressures involved.

Cylinder temperatures in a carbon dioxide compressor are usually somewhat higher than in an ammonia compressor, due to the higher pressures which will prevail.

It is interesting to know that mineral oil has no affinity for carbon dioxide, hence there is



Courtesy of Frigidaire Corp.

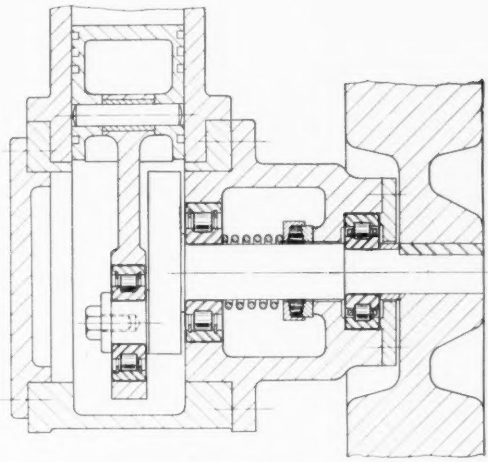
Fig. 15—Cut-away view of a Frigidaire Air Cooled compression unit which uses sulfur-dioxide as the refrigerant. The compressor is splash lubricated, oil which may work past the piston being returned to the base after accumulation in the header during the compression cycle.

little or no possibility of its being carried over into the condenser unless it is atomized. This latter is not likely to occur, however, when the oil is suited to the requirements, and the machine has been properly designed.

On the other hand, to insure against any oil whatsoever passing over into the system, an oil trap is usually installed in the discharge line from the compressor.

Stuffing boxes are built similar to those on a double-acting ammonia compressor, with the exception that the higher pressures involved require more compartments to prevent leakage.

Force-feed lubrication is the usual means provided for serving the piston rod and maintaining an adequate stuffing box seal. The same lubricator usually serves the compressor valves and piston as well. The feeding of a suitable amount of lubricant to the stuffing box prevents loss of gas.



Courtesy of Norma-Hoffmann Bearings Corp.

Fig. 16—Showing an adaptation of the roller bearing to a small single cylinder ammonia compressor. An interesting point is the small amount of space occupied by such bearings.

The lubricator must be very carefully adjusted at all times, however, the same as for an ammonia machine, since the feeding of an excessive supply of oil will often result in a certain amount of it passing to the gas relief line and thence into the system.

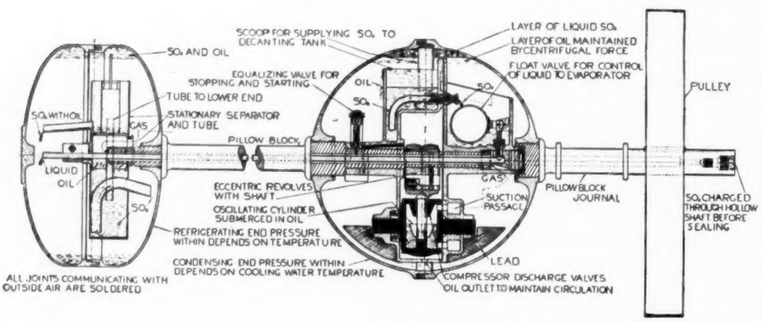
ETHYL AND METHYL CHLORIDES

Lubrication of ethyl and methyl chloride compressors is usually carried out with highly refined mineral oils, although chemically pure glycerine or ethylene glycol can also be employed. The former afford effective lubrication, provided they are kept out of contact with the refrigerants when they are in liquid form.

Where such contact occurs, more or less solution will result. There is but little probability of this happening, however, if the com-

pressors are properly designed and constructed. In vaporous state these refrigerants have but a slight tendency to dilute a petroleum product.

Glycerine and glycol are practically insoluble in both ethyl and methyl chlorides when these are in liquid form; therefore, they can be safely used in equipment where there may be probability of contact occurring between the refrigerant in liquid form and the lubricant.



Courtesy of Audiffren Refrigerating Machine Co.

Fig. 17—A dumb-bell type of sulfur dioxide machine. Details of construction are clearly indicated. The oil for such a machine must be a medium viscosity, specially refined petroleum product so prepared as to have no reaction with sulfur dioxide.

Compressors of both the reciprocating and rotary types are used in systems employing these chemicals. In the former, the essential principles of splash lubrication are involved.

In rotary compressors the lubricant goes through a continuous cycle, passing first to the bearings at each end of the machine and thence via ducts to the bearing compartments. The rotor blades pick the lubricant up at this stage and carry it into the cylinders, from whence it is discharged with the compressed gas to the condenser and separator.

In the latter, the lubricant, being the heavier, is separated from the refrigerant. From the separator, it is again forced to the compressor, to begin the cycle anew. The flow of lubricant is noted by means of the sight feed equipment or bull's-eyes which are generally installed in the circulating system.

HYDRO-CARBON REFRIGERANTS

In order to effectively lubricate compressors using hydro-carbon refrigerants, a lubricant must be selected that holds the refrigerant in solution as little as possible. Medium viscosity mineral oils of a high degree of refinement are suitable for such service, as are also certain glycerine blends such as glycol.

SULFUR DIOXIDE MACHINERY

Sulfur dioxide is another refrigerant whose machinery requires careful selection of the lubricant. Only the highest grade of mineral oil can be used, for like some other low pressure chemicals sulfur dioxide has a decided affinity for certain of the hydrocarbon components found in ordinary mineral lubricants. It is entirely possible to specially treat mineral oils of medium viscosities to remove the component parts affected by sulfur dioxide and render the residual oil quite satisfactory both as to chemical reaction, and solubility with respect to the refrigerant.

In certain household refrigerating systems, provision is made for removal of any lubricant that may have entered the system by means of a suitable return line. In others, oil traps or separators are employed in much the same manner as in an industrial ammonia or carbon dioxide system. Location of the evaporator or refrigerating side of the installation on a higher level than the compressor will permit of drainage of the lubricant back to the latter if it is present in either the coils or suction line.

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